DISCOVERY

Modeling the transport of fecal coliform, influenced by variation of deposition of micronutrients, velocity and dispersion coefficient in Ntanwaogba creek

Eluozo SN[1], Arimieari LW[2]

[1]Department of Civil Engineering, College of Engineering, Gregory University, Uturu, Abia State of Nigeria
[2]Department of Civil Engineering, Faculty of Engineering, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Nigeria

Citation
Eluozo SN, Arimieari LW. Modeling the transport of fecal coliform, influenced by variation of deposition of micronutrients, velocity and dispersion coefficient in Ntanwaogba creek. *Discovery*, 2021, 57(302), 113 - 128

ABSTRACT

Micronutrients in Ntanwaogba creek were observed to deposit at different station points of discharge, micronutrients are substrate utilization to microbial growth rate, but their transport rates are determined by the deposited velocity in the creek, while dispersion coefficient of the contaminant were to determine the rate of spread at different locations. Therefore, this paper tries to monitor the effect of these two parameters on the migration rate of fecal coliform at different point sources of discharge, the study monitors the growth rate at different station points. Based on these factors, the contaminants were observed to express gradual and rapid growth rates at different figures, but the rates of concentration expressed variation based on the predominant parameters that experienced pressure from the transport at different station points, the system observed the rate of velocities that exhibits higher concentration to be influenced by lower velocities, whereby accumulation including micronutrients increased their concentration. The velocities monitored at different station points expressed their pressure rates at different rate of concentrations in the study environment, the study from the simulation determined their various rates of pressure at various station points from these two parameters, the study has definitely expressed the rate of these two parameters pressures on the transport of fecal coliform in various figures that represent different point source of discharge examined. It has determined the extend effect of velocities of the creek flow and the variation deposition of different micronutrients at different point sources. The dispersions were also evaluated at different point sources based on predictive values from model simulation. The predictive and experimental values were compared for model validations, and both parameters expressed best fits correlations.

Keywords: Modeling, Transport, Fecal coliform, micronutrients and Dispersion coefficient

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

INTRODUCTION

Health risks induced by water borne pathogens are extensively reported as serious. The sources of impairment based on these conditions is clear that the rate of pollution if not controlled will always generate serious hazards to environmental health in general, experts were able to evaluate the cost of implementing total maximum daily load (TMDL), this amounts to estimated cost of $0.9 to $4.3 billion per year (USEPA, 2010b, Pandey 2012). The influxes of Pathogen into streams through agriculture activities on land are the main cause of stream impairments (USEPA, 2012). Meanwhile to Control pathogen contaminations from livestock is a very serious challenge. There is no doubt that pathogen contamination can be prevented, this could be by fencing off riparian buffers; another is if buffers are useful in controlling stream water pathogens, it is not also ascertained about the width that they must be (Nagels et al., 2002). Research has thoroughly reviewed studies on this area; this has elaborated the stream water pathogen contamination (Jamieson et al., 2004; Pachepsky et al., 2006). Several studies have also emphasized applying mathematical models to understand pathogen transport in stream water, these were carried out by (Kim et al., 2010; Muirhead et al., 2004; Jamieson et al., 2005a; Jamieson et al., 2005b). Moreover in numerous countries, the application of surface reservoirs serve as the main source of drinking water, this implies that these surface water bodies are often open to to pathogen pollution (Kistemann et al., 2002). In the developed nations around the world, there is serious increased awareness of water qualities and water treatment for pathogen pollutions because experts monitored the outbreaks of 26 water-borne diseases via public water supplies; these were carried out by (Gibson et al., 1998; Howe et al., 2002; Brookes et al., 2004). Furthermore, during the rainy seasons, the influx of polluted water from streams to lakes and reservoirs can increase pathogen rates significantly (Kistemann et al., 2002). The amount of pathogen influx from lakes' and reservoirs' tributaries during rainy seasons is of particular significance in determining and monitoring of pathogen transport including its distribution (Brookes et al., 2004).

THEORETICAL BACKGROUND

Governing Equation

$$\frac{dc}{dx}+\beta(x)K=A(x) \qquad (1)$$

Nomenclatures

C = Concentration

B = Micronutrients

K = Dispersions. Velocity of flow

A= Fluid Density

X = Distance

Multiplying the equation through by $C[x]$, we have:

$$C(x)\frac{dC}{dx}+C(x)\beta(x)K=C(x)A(x) \qquad (2)$$

Let $P(x)=C(x)\beta(x)$ 3

Then Equation (2), we have:

$$C(x)\frac{dC}{dx}+C(x)\beta(x)K=C(x)A(x) \qquad (4)$$

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

$$C(x)\frac{dC}{dx}+P(x)K=C(x)A(x) \qquad (5)$$

$$\boxed{C(x)P^{1}+P(x)K=C(x)A(x)} \qquad (6)$$

$$C(x)P^{1}=C(x)A-P(x)K \qquad (7)$$

Differentiate 2nd term on the left hand side of(6) with respect to x, we have

$$K\frac{dC}{dx}=C(x)A(x)-C(x)P^{1} \qquad (8)$$

$$\frac{dC}{dx}=\frac{1}{K}\left[C(x)A(x)-C(x)P^{1}\right] \qquad (9)$$

$$\frac{dC}{dx}=\frac{C(x)}{K}\left[A(x)-P^{1}\right] \qquad (10)$$

Applying separation of variables, by dividing through by C(x) and cross multiply by dx, gives:

$$\frac{dC}{C}=\frac{1}{K}\left[A(x)-P^{1}\right]dx \qquad (11)$$

$$\frac{1}{C(x)}dC=\frac{1}{K}\left[A(x)-P^{1}\right]dx \qquad (12)$$

$$\frac{1}{C(x)}dC=\left(\frac{A(x)}{K}-\frac{P^{1}}{K}\right)dx \qquad (13)$$

$$\int\frac{1}{C(x)}dC=\int\left(\frac{A(x)}{K}-\frac{P^{1}}{K}\right)dx+\eta \qquad (14)$$

$$\ln C(x)=\int A(x)dx-\int\frac{P^{1}}{K}dx+\eta \qquad (15)$$

$$\ln C(x)=\frac{1}{K}\left[Ax-P^{1}\right]x+\eta \qquad (16)$$

$$\ln C(x)=\left(\frac{A(x)}{K}-\frac{P^{1}}{K}\right)x+\eta \qquad (17)$$

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Taking exponent of the both side of the equation

$$C(x) = \ell^{\left(\frac{A(x)}{K} - \frac{P^1}{K} + \eta\right)} \quad \text{..} \quad 18$$

$$C(x) = D\ell^{\frac{1}{K}\left(Ax - P^1 x\right)} \quad \text{..} \quad 19$$

MATERIALS AND METHOD

Standard laboratory experiment where performed to monitor fecal coliform using the standard method for the experiment at different sample at different station, the water sample were collected in sequences base on specification stipulated at different locations, this samples collected at different location generated variations at different distance producing different fecal coliform concentration through physiochemical analysis, the experimental result were compared with the theoretical values for model validation.

RESULTS AND DISCUSSION

Table 1: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

Distance [x]	**Predictive Values Conc.[Mg/L] Variation of Velocity and Dispersion Coefficient [0.0042/27.5]**	**Experimental Values Conc.[Mg/l] Variation of Velocity and Dispersion [0.0042/27.5]**
2	0.126042926	0.03112
4	0.137548218	0.10196
6	0.150103721	0.16624
8	0.1638053	0.22468
10	0.17875757	0.278
12	0.195074694	0.32692
14	0.212881257	0.37216
16	0.232313216	0.41444
18	0.253518939	0.45448
20	0.276660336	0.493
22	0.301914097	0.53072
24	0.32947304	0.56836
26	0.359547584	0.60664
28	0.392367355	0.64628
30	0.428182938	0.688
32	0.467267795	0.73252
34	0.509920346	0.78056
38	0.607260908	0.89008
40	0.662692134	0.953
42	0.723183165	1.02232
44	0.789195861	1.09876
46	0.861234246	1.18304
48	0.939848348	1.27588

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

50	1.025638403	1.378
54	1.221426272	1.61296
56	1.332918969	1.74724
58	1.454588803	1.89368
60	1.587364749	2.053
62	1.732260583	2.22592
64	1.890382616	2.41316
66	2.062938146	2.61544
68	2.251244672	2.83348
70	2.456739959	3.068
72	2.680993007	3.31972
74	2.925716041	3.58936
76	3.192777575	3.87764
78	3.484216684	4.18528
80	3.802258571	4.513
82	4.149331558	4.86152
84	4.528085626	5.23156
86	4.941412646	5.62384
88	5.392468463	6.03908
90	5.884696991	6.478

Table 2: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

Distance [x]	**Predictive Values Conc.[Mg/L] Variation of Velocity and Dispersion Coefficient [0.0032/29.9]**	**Experimental Values Conc.[Mg/l] Variation of Velocity and Dispersion [0.0032/29.9]**
2	0.102408622	0.0387048
4	0.111096671	0.1027384
6	0.12052179	0.1668296
8	0.130746508	0.2310072
10	0.141838662	0.2953
12	0.153871841	0.3597368
14	0.166925881	0.4243464
16	0.181087387	0.4891576
18	0.196450315	0.5541992
20	0.213116588	0.6195
22	0.23119678	0.6850888
24	0.250810842	0.7509944
26	0.272088905	0.8172456
28	0.295172137	0.8838712
30	0.320213683	0.9509
32	0.34737968	1.0183608

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

34	0.376850362	1.0862824
38	0.443504458	1.2236232
40	0.481130086	1.2931
42	0.521947764	1.3631528
44	0.566228295	1.4338104
46	0.614265457	1.5051016
48	0.666377952	1.5770552
50	0.72291152	1.6497
54	0.850773977	1.7971784
56	0.922951168	1.8720696
58	1.001251662	1.9477672
60	1.086194941	2.0243
62	1.178344562	2.1016968
64	1.278311889	2.1799864
66	1.386760152	2.2591976
68	1.504408852	2.3393592
70	1.632038525	2.4205
72	1.770495928	2.5026488
74	1.920699654	2.5858344
76	2.083646229	2.6700856
78	2.260416716	2.7554312
80	2.452183898	2.8419
82	2.66022005	2.9295208
84	2.885905385	3.0183224
86	3.130737206	3.1083336
88	3.396339848	3.1995832
90	3.684475446	3.2921

Table 3: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

Distance [x]	**Predictive Values Conc.[Mg/L] Variation of Velocity and Dispersion Coefficient [0.0028/29.9]**	**Experimental Values Conc.[Mg/l] Variation of Velocity and Dispersion [0.0028/29.9]**
2	0.071382281	0.00900792
4	0.077438146	0.04106336
6	0.084007773	0.07321384
8	0.091134748	0.10550688
10	0.098866355	0.13799
12	0.107253889	0.17071072
14	0.116352997	0.20371656
16	0.126224047	0.23705504
18	0.136932529	0.27077368

ISSN 2278–5469 EISSN 2278–5450 | OPEN ACCESS

20	0.148549486	0.30492
22	0.161151993	0.33954152
24	0.174823659	0.37468576
26	0.18965519	0.41040024
28	0.205744985	0.44673248
30	0.223199791	0.48373
32	0.242135413	0.52144032
34	0.262677477	0.55991096
38	0.309137641	0.63932328
40	0.33536398	0.68036
42	0.363815285	0.72234712
44	0.394680316	0.76533216
46	0.428163846	0.80936264
48	0.464488022	0.85448608
50	0.503893835	0.90075
54	0.593018302	0.99688936
56	0.643328251	1.04685984
58	0.697906349	1.09816088
60	0.757114694	1.15084
62	0.821346104	1.20494472
64	0.891026719	1.26052256
66	0.966618835	1.31762104
68	1.048623967	1.37628768
70	1.137586175	1.43657
72	1.234095678	1.49851552
74	1.338792768	1.56217176
76	1.452372053	1.62758624
78	1.575587076	1.69480648
80	1.709255302	1.76388
82	1.854263552	1.83485432
84	2.01157388	1.90777696
86	2.18222996	1.98269544
88	2.367364004	2.05965728
90	2.568204283	2.13871

Table 4: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

Distance [x]	Predictive Values Conc.[Mg/L] Variation of Velocity and Dispersion Coefficient [0.0011/17.5]	Experimental Values Conc.[Mg/l] Variation of Velocity and Dispersion [0.0011/17.5]
2	0.022082347	-0.03668
4	0.02533143	0.11156

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

6	0.029058567	0.23564
8	0.033334096	0.33748
10	0.038238704	0.419
12	0.043864952	0.48212
14	0.050319016	0.52876
16	0.057722699	0.56084
18	0.066215721	0.58028
20	0.075958364	0.589
22	0.087134489	0.58892
24	0.099955012	0.58196
26	0.114661881	0.57004
28	0.131532644	0.55508
30	0.150885684	0.539
32	0.173086231	0.52372
34	0.198553254	0.51116
38	0.261279889	0.50188
40	0.299723275	0.509
42	0.343823024	0.52652
44	0.394411385	0.55636
46	0.452443059	0.60044
48	0.519013216	0.66068
50	0.595378165	0.739
54	0.783469107	0.95756
56	0.898744744	1.10164
58	1.030981448	1.27148
60	1.182674783	1.469
62	1.356687501	1.69612
64	1.556303559	1.95476
66	1.785290103	2.24684
68	2.047968555	2.57428
70	2.349296171	2.939
72	2.694959591	3.34292
74	3.091482159	3.78796
76	3.546347028	4.27604
78	4.068138387	4.80908
80	4.666703457	5.389
82	5.35333833	6.01772
84	6.141001145	6.69716
86	7.044556637	7.42924
88	8.081056661	8.21588
90	9.270061997	9.059

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Table 5: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

Distance [x]	Predictive Values Conc.[Mg/L] Variation of Velocity and Dispersion Coefficient [0.0021/17.5]	Experimental Values Conc.[Mg/l] Variation of Velocity and Dispersion [0.0021/15.5]
2	0.038006482	-0.469408
4	0.044377655	-0.421408
6	0.051816852	-0.341408
8	0.060503111	-0.229408
10	0.070645481	-0.085408
12	0.082488055	0.090592
14	0.096315846	0.298592
16	0.112461642	0.538592
18	0.131314021	0.810592
20	0.153326697	1.114592
22	0.179029442	1.450592
24	0.209040837	1.818592
26	0.244083159	2.218592
28	0.284999759	2.650592
30	0.332775368	3.114592
32	0.388559786	3.610592
34	0.45369556	4.138592
38	0.61855438	5.290592
40	0.722245035	5.914592
42	0.843317755	6.570592
44	0.984686361	7.258592
46	1.149753131	7.978592
48	1.342490681	8.730592
50	1.567537569	9.514592
54	2.137131844	11.178592
56	2.495387493	12.058592
58	2.913698918	12.970592
60	3.4021335	13.914592
62	3.972446253	14.890592
64	4.638362732	15.898592
66	5.415909357	16.938592
68	6.32379912	18.010592
70	7.383881944	19.114592
72	8.621670538	20.250592
74	10.06695441	21.418592
76	11.75451678	22.618592
78	13.72497174	23.850592
80	16.02574166	25.114592

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

82	18.71219851	26.410592
84	21.84899648	27.738592
86	25.51162799	29.098592
88	29.78824053	30.490592
90	34.78175812	31.914592

Table 6: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

Distance [x]	Predictive Values Conc.[Mg/L] Variation of Velocity and Dispersion Coefficient [0.035/26.5]	Experimental Values Conc.[Mg/l] Variation of Velocity and Dispersion [0.035/26.5]
2	1.015504788	3.651
4	1.111859812	2.899
6	1.217357372	2.235
8	1.33286495	1.659
10	1.459332333	1.171
12	1.597799431	0.771
14	1.749404823	0.459
16	1.915395121	0.235
18	2.09713522	0.099
20	2.296119523	0.051
22	2.513984227	0.091
24	2.752520777	0.219
26	3.013690598	0.435
28	3.299641222	0.739
30	3.612723947	1.131
32	3.955513173	1.611
34	4.330827566	2.179
38	5.191669134	3.579
40	5.684274788	4.411
42	6.223620772	5.331
44	6.81414199	6.339
46	7.460694146	7.435
48	8.168593671	8.619
50	8.943661443	9.891
54	10.72139917	12.699
56	11.738687	14.235
58	12.85249904	15.859
60	14.07199387	17.571
62	15.4071991	19.371
64	16.86909376	21.259
66	18.46969864	23.235

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

68	20.2221751	25.299
70	22.14093331	27.451
72	24.24175073	29.691
74	26.54190183	32.019
76	29.06030016	34.435
78	31.81765388	36.939
80	34.83663598	39.531
82	38.14207078	42.211
84	41.76113802	44.979
86	45.72359637	47.835
88	50.0620281	50.779
90	54.81210701	53.811

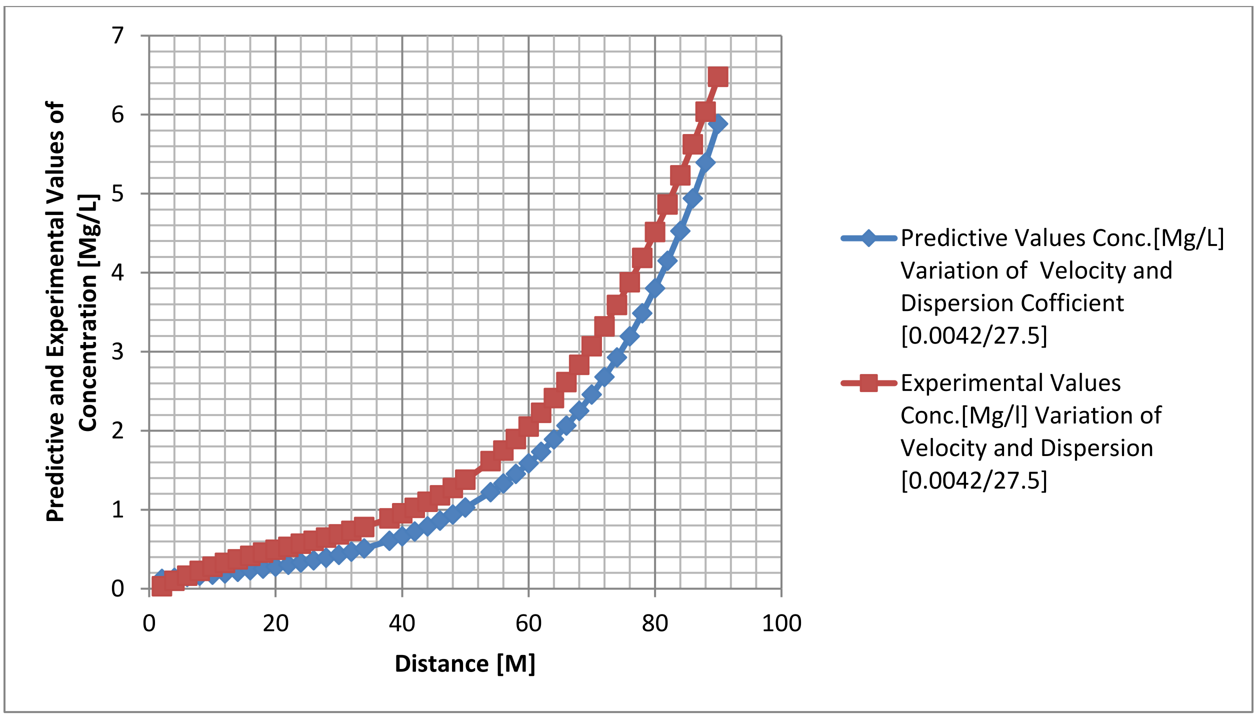

Figure 1: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

The figure presented explained the exponential growth rate of the contaminant in terms it variation of rapid and gradual increase with respect to increase in distance; figure 1-6 shows the migration rate of Fecal coliform based the predominant influential parameters in the study environment. The behaviour of the growth rate expressed some level of variations, but on the exponential phase of the transport system, the variations observed are basically the rate of micronutrient depositions including dispersion from the contaminant at different station point, where the initial concentration are monitored. such condition implies that the micronutrient being substrate utilization to any microbes determined the variation rate of concentration at different study locations, this condition were examined on the flow dynamic that pressured the microbes at different station point of discharge, these are the pressure from the transport that were examined in the study, the depositions of micronutrient observed in the creek are of various types, as a substance there depositions observed variations, these influenced the growth rate of fecal coliform in the study area as expressed in graphical representation in all the figures, while that of the velocities of flow expressed its variations based on the rates of migration in creek, the behaviour of the microbes in terms of growth rates are pressured by the reactions from the variation of the micronutrients and the velocities depositions in the creek, the application of modeling and simulation monitored the behaviour of

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

fecal coliform through the examination on the variation effect of the contaminant transport in various station point of discharge. The predictive and experimental values in all the figures developed best fits correlations.

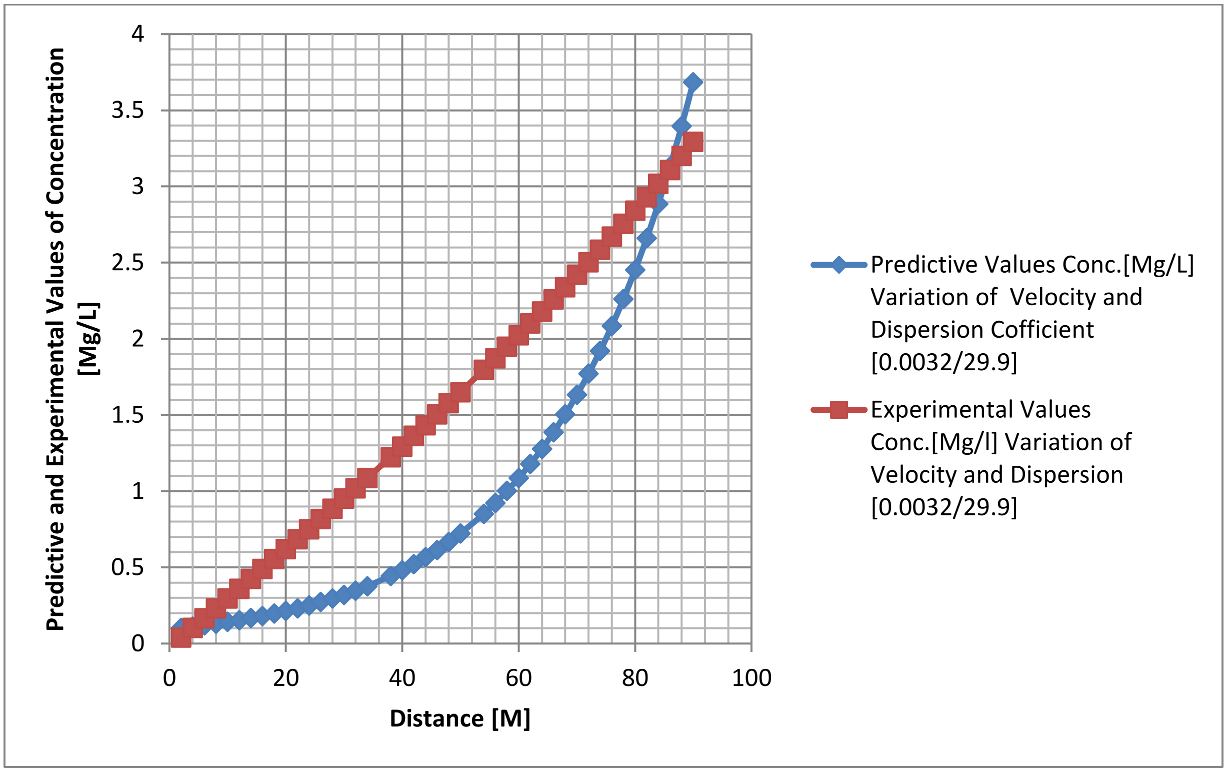

Figure 2: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

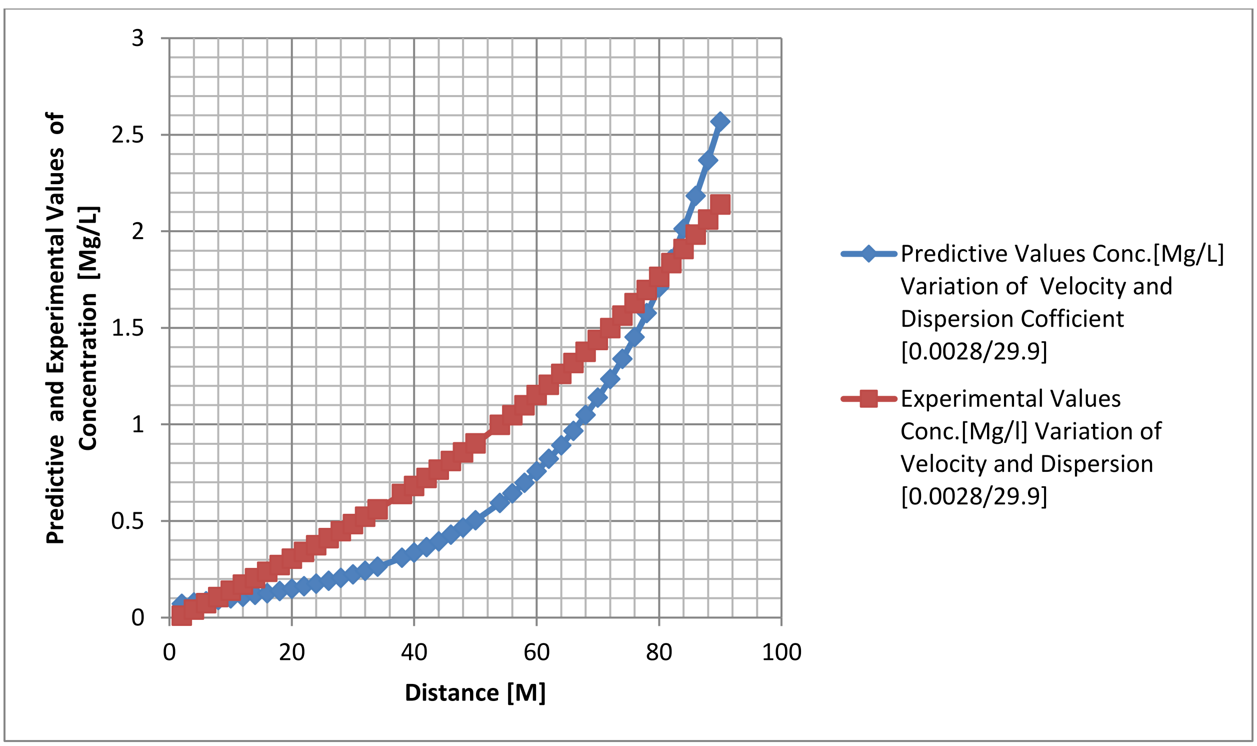

Figure 3: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

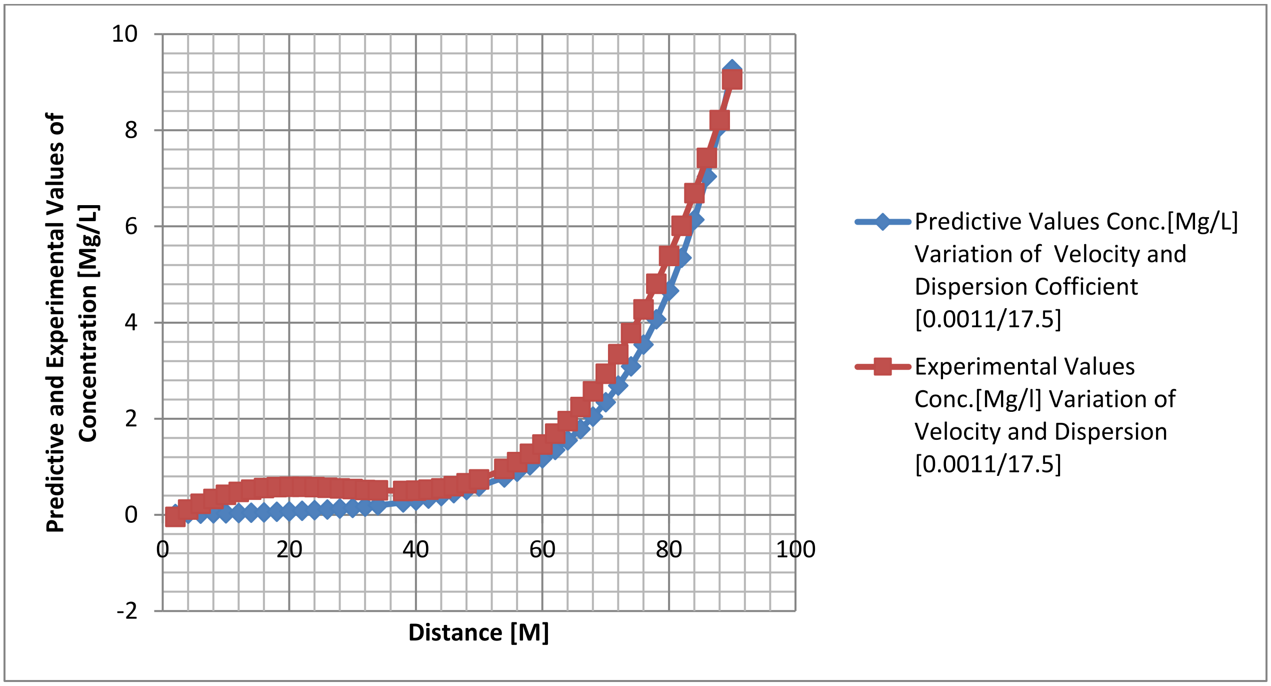

Figure 4: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

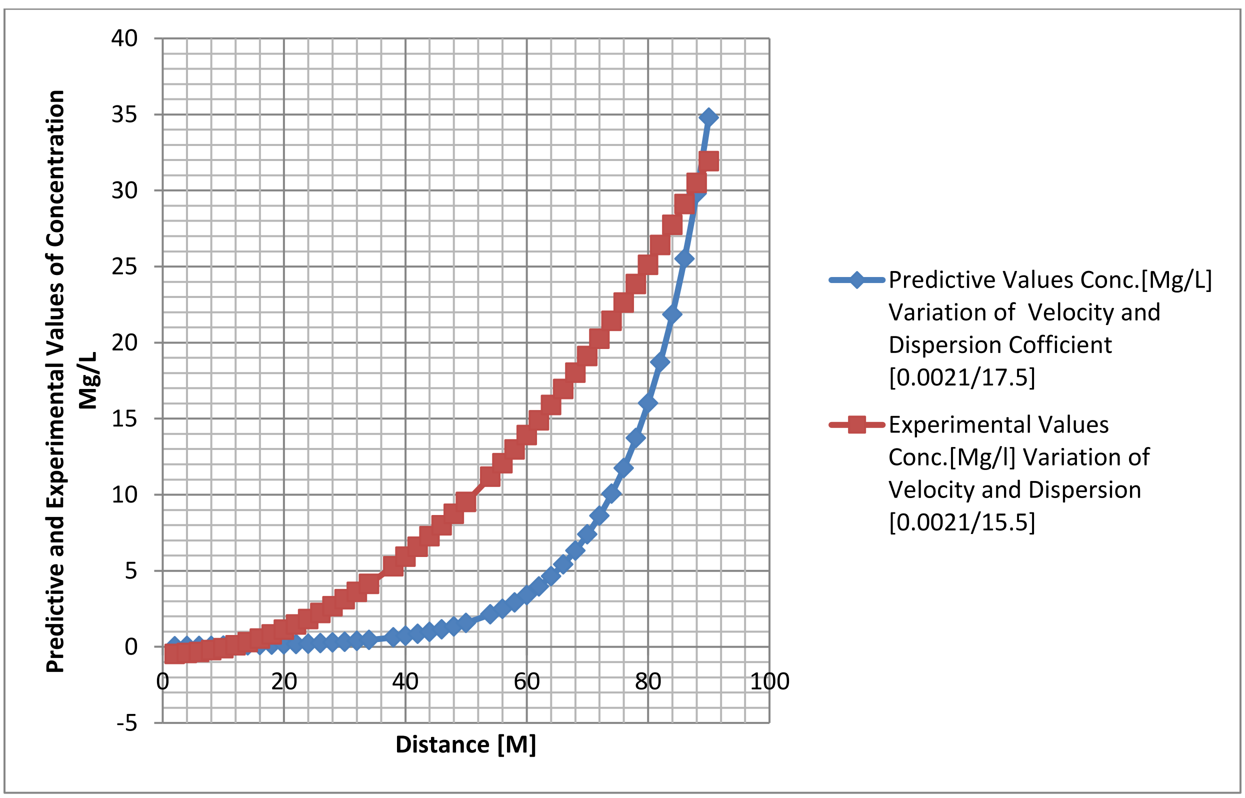

Figure 5: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

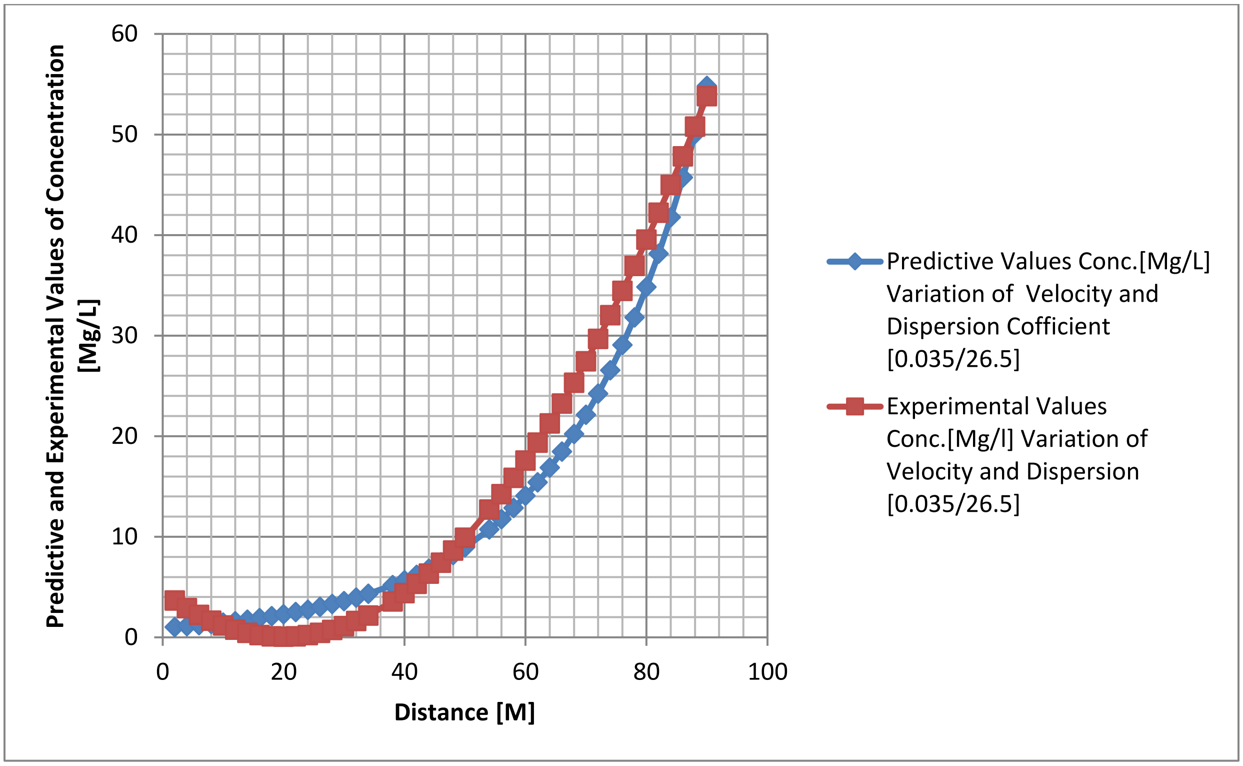

Figure 6: Predictive and Experimental Values of fecal coliform Concentration at Different Distance

CONCLUSION

Velocities of fecal coliform in Ntanwaogba creek was examined using modeling and simulation, the system monitor the behaviour of the contaminant in different station point of discharge observed in study environment, the station point were monitored applying experimental approach, this developed variation in concentration at different station with constant distance, the behaviour of the microbes in terms of growth were evaluated, gradual and rapid increase in concentration were observed in the study, the pressure from micronutrient, dispersion coefficient and velocities of flows were considered as predominant parameters that is influential to the transport system of the contaminant. The behaviour fecal coliform in the creek were evaluated to determined the factors that pressured it transport behaviour, the substances observed from micronutrient in various stations that validates the behaviors were observed to increase at different station points thus expressed their variation of effect in gradual and rapids state of growth on the concentration, this implies that the substance regenerate based on constant discharge also of the micronutrient in the creek, the experimental analysis were compared with predictive values, and both parameters developed best fits correlation, the study is imperative because it determined the variations rate of micronutrients, velocities of flow in different station points of discharge, it has expressed the variation effect of velocities of flows and dispersion on fecal coliform transport in different point source of discharge.

Funding:
This study has not received any external funding.

Conflict of Interest:
The authors declare that there are no conflicts of interests.

Peer-review:
External peer-review was done through double-blind method.

Data and materials availability:
All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Eluozo S.N, Ezeilo F. E. Numerical Modeling of Nocardia Migration Influenced Transport Pressured by Dispersion and Velocity in Fine Sand Formation in Wetland Environment, *Journal of Water Resources Engineering and Management 2018 Vol. 5 Issue 1 Pp,25-32*
2. Eluozo S.N, Ezeilo F. E. Modeling Heterogeneous Porosity in Alluvia Plain Deposition in Deltaic Formation; *Recent Trend in Civil Engineering & Technology 2018.Vol, 8 Issues (2): Pp1-10.*
3. Ezeilo F.E, Eluozo S.N. Dispersion and Storage Coefficient Influences on Accumulation of Frankia Transport in Heterogeneous Silty and Fine Sand Formation, Warri Delta State of Nigeria; *International Journal of Mechanical and Civil Engineering Vol. 4 Issue 4 April 2018Pp. 1-16.*
4. Eluozo S.N, Amadi C.P, Modeling and Simulation of Legionella Transport Influenced by Heterogeneous Velocity in Stream. *Journal of Water Resource Engineering and Management*. *2019; 6 (2):25– 31P*
5. Eluozo S.N, Amadi C.P, velocity and Oxygen Deficit Influence on the TransportofFrancisela in Eleme Creek. *Journal of Water Resource Engineering and Management*. 2019; 6(2):43–48p
6. *Eluozo. S. N, Afiibor. B.B.* Mathematical Model to Monitor the Transport of Bordetella Influenced by Heterogeneous Porosity in Homogeneous Gravel Depositions. *Journal of Geotechnical Engineering Vol. 6, No 1 (2019)*
7. Ezeilo F.E, Eluozo S.N. Linear Phase Velocity Effect on Accumulation of Zinc in Homogeneous Fine Sand Applying Predictive Model, *International Journal of Mechanical and Civil Engineering Vol. 4 Issue 4 April 2018, Pp. 17-32.*
8. Eluozo S.N, Ezeilo F. E. Predicting the Behaviour of Borrelia in Homogeneous Fine Sand in Coastal Area of Bakana *Recent Trend in Civil Engineering & Technology 2018.Vol, 8 Issue (2): Pp1-19.*
9. Eluozo S.N, Oba A.L Modeling and simulation of cadmium transport influenced by high degree of saturation and porosity on homogeneous coarse depositions MOJ Civil Engineering Vol. 4 issue 4.2018
10. Eluozo SN, Afiibor B.B. Dispersion and dynamics influences from phosphorus deposition on e-coli transport in coastal deltaic Lake, MOJ Applied Bionics and biomechanics 2018 Vol. 2 Issue 5
11. Eluozo S.N, Oba A.L Predicting heterogeneous permeability coefficient pressured by heterogeneous seepage on coarse deposition MOJ Civil Engineering Vol. 4 issue 4.2018
12. Brookes, J.D., Antenucci, J., Hipsey, M., Burch, M.D., Ashbolt, N.J. and Ferguson, C. (2004) Fate and transport of pathogens in lakes and reservoirs. Environment International 30(5), 741-759.
13. Howe, A.D., Forster, S., Morton, S., Marshall, R., Osborn, K.S., Wright, P. and Hunter, P.R. (2002) *Cryptosporidium* oocysts in a water supply associated with a cryptosporidiosis outbreak. Emerging Infectious Diseases 8(6), 619-624.
14. Gibson, C.J., Haas, C.N. and Rose, J.B. (1998) Risk assessment of waterborne protozoa: current status and future trends. Parasitology 117, S205-S212
15. Nagels, J.W., Davies-Colley, R.J., Donnison, A.M. and Muirhead, R.W. (2002) Faecal contamination over flood events in a pastoral agricultural stream in New Zealand. Water Science and Technology 45(12), 45-52
16. Pachepsky, Y.A., Sadeghi, A.M., Bradford, S.A., Shelton, D.R., Guber, A.K. and Dao, T. (2006) Transport and fate of manure-borne pathogens: Modeling perspective Agricultural Water Management 86(1-2), 81-92.
17. Jamieson, R., Gordon, R., Joy, D. and Lee, H. (2004) Assessing microbial pollution of rural surface waters: A review of current watershed scale modeling approaches. Agricultural Water Management 70(1), 1-17.
18. Jamieson, R., Joy, D.M., Lee, H., Kostaschuk, R. and Gordon, R. (2005a) Transport and deposition of sediment-associated Escherichia coli in natural streams. Water Research 39(12), 2665-2675.
19. Jamieson, R.C., Joy, D.M., Lee, H., Kostaschuk, R. and Gordon, R.J. (2005b) Resuspension of sediment-associated Escherichia coli in a natural stream. Journal of Environmental Quality 34(2), 581-589.
20. Kim, J.W., Pachepsky, Y.A., Shelton, D.R. and Coppock, C. (2010) Effect of streambed bacteria release on E. coli concentrations: Monitoring and modeling with the modified SWAT. Ecological Modeling 221(12), 1592-1604.
21. Muirhead, R.W., Davies-Colley, R.J., Donnison, A.M. and Nagels, J.W. (2004) Faecal bacteria yields in artificial flood events: quantifying in-stream stores. Water Research 38(5), 1215-1224.
22. Kistemann, T., Classen, T., Koch, C., Dangendorf, F., Fischeder, R., Gebel, J., Vacata, V. and Exner, M. (2002) Microbial load of drinking water reservoir tributaries during extreme rainfall and runoff. Applied and Environmental Microbiology 68(5), 2188- 2197.
23. Pandey P. K. 2012 Modeling In- Stream Escherichia coli Concentrations Graduate Dissertation Iowa state university pp62-75
24. U.S. Environmental Protection Agency (2010a) WATERS (Watershed Assessment, Tracking & Environmental Results). Washington, D.C.
25. US Environmental Protection Agency (US EPA) (2012). Impaired waters and total maximum daily loads.

ISSN 2278–5469 EISSN 2278–5450 | OPEN ACCESS

http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm (accessed on 4.12.11).

Peer-review
External peer-review was done through double-blind method.

Article History
Received: 17 November 2020
Reviewed & Revised: 18/November/2020 *to* 30/December/2020
Accepted: 02 January 2021
Prepared: 04 January 2021
Published: February 2021